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ANT COMMUNITIES AS BIO-INDICATORS IN RELATION TO FIRE MANAGEMENT OF SPOTTED GUM (*EUCALYPTUS MACULATA* HOOK.) FORESTS IN SOUTH-EAST QUEENSLAND

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Abstract

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As a pilot test of the potential for using ant communities as bio-indicators in forest monitoring programs, the effects of different fire regimes on ant community structure were studied at Bauple State Forest in 1994 and 1995. Three sites had been subjected to long-term burning regimes of: annual burning; periodic burning (2–3 years); and no burning. Two grids of pitfall traps were established in each compartment, and ants were sampled monthly between May 1994 and April 1995. A total of 88 species from 42 genera were recorded, with 74 species found from the annually burned site, 63 from the periodically burned site, and 43 from the unburned site. The relative abundance of Eyrean (arid) taxa was particularly high (36%), and that of Bassian (cool temperate) taxa low (8%) at the annually burned site, with the reverse true for the unburned site (14% and 20% respectively). Burning frequency also affected the dominance of functional groups. The relative abundance of Dominant Dolichoderinae (species of *Iridomyrmex*) was positively related to fire frequency, while Opportunists (mostly species of *Rhytidoponera*) comprised 65% of all ants at the unburned site, but only 16% at the annually burned site. These site differences conform to known ant-fire-habitat relationships elsewhere in Australia. We have not only shown that ant communities are sensitive to fire management practices in Bauple State Forest, but have demonstrated that an effective ant sampling program is a practicable option.

Introduction

There is increasing interest in the use of 'indicator' groups of invertebrates for assessing and monitoring ecological change associated with land management practices (Rosenberg et al., 1986; Noss, 1990; Spellerberg, 1993; Williams, 1993). In the context of forest management, a variety of major disturbances (including timber harvesting, fire and grazing) have the potential to be monitored using indicator groups. Such monitoring has traditionally focused on vascular plants and vertebrates, but there is growing acknowledgement that these taxa provide a limited view of the state of an ecosystem after disturbance. A more reliable indication of ecosystem health is likely to be provided by invertebrates (Rosenberg et al., 1986; Spellerberg, 1993; Williams, 1993), and the recent development of rapid biodiversity assessment techniques (Oliver and Beattie, 1993, 1996) makes invertebrates a realistic monitoring option.

Ants are ideal candidates for use as bio-indicators in the Australian environment because:

1. they are highly abundant and diverse in most habitats;
2. they are functionally important at all trophic levels;
3. they can be sampled and sorted with relative ease;
4. species composition is highly sensitive to ecological change; and
5. species can be classified into functional groups which vary predictably in relation to environmental stress and disturbance (Majer, 1983; Greenslade and Greenslade, 1984; Andersen, 1990, 1995).

Ants have a long history of use as bio-indicators of restoration success following mining (Majer, 1983, 1984, 1985; Andersen 1993a), and more recently have been incorporated into forestry monitoring programs, especially in relation to fire (Neumann, 1992; York, 1994).

The Queensland Forestry Research Institute has recently established a pilot ant survey program as a basis for their potential use as indicators of the ecological effects of forest management practices (Vanderwoude et al., submitted). Ants have been surveyed at sites subject to different burning regimes, and the differences in ant communities at these sites are reported here.

Methods

Study site

Our study was conducted in Bauple State Forest (25° 55′S, 152° 40′E), approximately 225 km N of Brisbane in south-east Queensland. The area is part of the humid subtropics (Brown and Turnbull, 1986). Mean annual rainfall is 1100 mm, with over 50% falling in the summer months between December and March.

Bauple State Forest consists mainly of open eucalypt forest with an understorey of *Acacia* species. Dominant canopy trees are *Eucalyptus maculata* Hook. and *Eucalyptus drepanophylla* F. Muell. ex Benth., while the main understorey trees are *Acacia aulacocarpa* Cunn. ex Benth. and *Acacia leiocalyx* (Domin) Pedley. *Alphitonia excelsa* (Cunn. ex Fenzl) Reissack ex Benth. and the introduced weed *Lantana camara* L. are also common in the understorey where the soils are deeper and more fertile.

Three sites within the forest had been subjected to experimental burning regimes as follows:

1. annually burned (314 ha) by spring fires since 1952;
2. periodically burned (423 ha) by spring fires every 2–3 years since 1973; and
3. unburned (296 ha) since at least 1946.

Annual and periodic burning have resulted in the development of a grassy ground layer and a reduction of woody understorey plants, while the absence of fire at the unburned site has resulted in a heavy litter layer and the establishment of a greater proportion of fire-sensitive understorey plants in favour of grasses (Henry, 1961; Henry and Florence, 1966; House, 1995).

Sampling

Ants were sampled by pitfall traps within two plots at each site. These were selected to capture within-site variation, and do not represent treatment replicates. Nine pitfall traps (18 mm o.d. test tubes inserted in permanent sleeves, following Majer, 1978) were established in each plot, as a 3 x 3 array with 5-m spacing. Preservative was 70% ethanol to which a small quantity of glycerol had been added. Digging-in effects (Greenslade, 1973) were minimised by establishing plots several weeks prior to opening the trapps. Pitfalls were opened for seven days each month from May 1994 to April 1995.

Analysis

Ants were sorted to species, and species abundances in each trap were square-root transformed to avoid distortions caused by large numbers of individuals falling into a few traps (Southwood, 1978; Andersen, 1983, 1991). A species' total abundance was defined as the sum of transformed abundances from individual traps. Data from the two plots within a site were pooled for all analyses. Details of ant species composition are given elsewhere (Vanderwoude et al., submitted), and the analyses presented here are restricted to site comparisons of species richness, biogeographic profiles, and functional group composition.

Each species was described as having Eyrean (arid), Bassian (cool-temperate) or Torresian (tropical) affinities, or as being Widespread, according to the distribution of the species-group to which it belongs. Such designations were based on the second author's understanding of the biogeography of the Australian ant fauna, following and extending those published elsewhere (e.g. Andersen, 1993a; 1993b). Species were classified into functional groups according to their habitat requirements and competitive interactions, following Greenslade (1978) and Andersen (1990, 1995). These groups are: Dominant Dolichoderinae; Subordinate Camponotini; Hot, Cold, and Tropical climate specialists; Cryptic species; Opportunists; Generalised Myrmicinae; and Specialist Predators. Ant species richness and composition were compared across sites. The relative abundances of Dominant Dolichoderinae, Generalised Myrmicinae, and Opportunists were used to classify the ant communities of each plot following Andersen (1995) as a tool for exploring the possible impact of disturbance (fire) on community structure.

Results

A total of 88 species from 42 genera were recorded, with species richness being greatest at the annually burned site (74 species), least at the unburned site (43 species) and intermediate at the periodically burned site (63 species). These site differences were not simply artefacts of increased 'trappability' at burned sites following fire-induced habitat modification (Vanderwoude et al., submitted).

Most of the 88 species recorded represented either Widespread (40%) or Bassian (29%) taxa, with 20% and 11% having Torresian and Eyrean affinities respectively. The relative abundance of Eyrean taxa was particularly high (36%), and that of Bassian taxa low (8%) at the annually burned site, with the reverse true for the unburned site (14% and 20% respectively; Fig. 1). Ants from Widespread species-groups dominated each site, with the relative abundance of this group inversely related to frequency of burning.

The most abundant functional groups were Generalised Myrmicinae (particularly species of *Pheidole* — 31% of total ants), Opportunists (particularly species of *Rhytidoponera* — 28%) and Dominant Dolichoderinae (species of *Iridomyrmex* — 27%). Together, these three groups accounted for 86% of total abundance and 41% of species richness. The relative abundances of functional groups varied markedly across sites (Fig. 2). The relative abundance of Dominant Dolichoderinae was positively related to fire frequency. Conversely, Opportunists comprised 65% of all ants at the unburned site, but only 16% at the annually burned site. Following Andersen (1995), ant community classifications at the annually burned, periodically burned, and unburned sites are DD3GM, DD2GM and DD1OPP respectively.

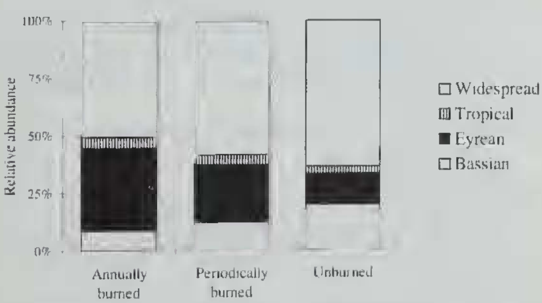

Figure 1 Relative abundance of ants from each biogeographical group.

Figure 2 Relative abundance of the three major functional groups at each site.

Discussion

Ant community response to fire

Site species richness, biogeographical profiles, and functional group composition all varied systematically with fire frequency. With increasing fire frequency, species richness increased, the relative abundances of Eyrean taxa and Dominant Dolichoderinae increased, and the relative abundances of Bassian taxa and Opportunists decreased. Although the lack of treatment replication places constraints on the validity of attributing these site differences to the effects of fire, the differences in vegetation structure are known to be due to fire (Henry, 1961; Henry and Florence, 1966; House, 1995), and the above variation in ant community structure is consistent with these differences. In northern Australia, greatest ant diversity occurs in open (savanna) habitats, and the rainforest fauna is relatively depauperate (Taylor, 1972; Andersen and Majer, 1991; Andersen, 1992). Open habitats are dominated by species of *Iridomyrmex* (Dominant Dolichoderinae), many of which have Eyrean affinities (Andersen 1993b). Species of *Iridomyrmex* are commonly absent from heavily shaded habitats, where Opportunists are often the most abundant ants (Andersen and Majer, 1991; Andersen and Reichel, 1994; Reichel and Andersen, 1996), reflecting a lack of competition from behaviourally dominant ants.

These fire-habitat-ant relationships are reflected in the ant community classifications of each site. In a national context, DD2GM (periodically burned) and DD3GM (annually burned) communities are characteristic of open sites experiencing warm climates, whereas DD1OPP (unburnt) communities are characteristic of shady environments (Andersen, 1995).

The responses of ant communities to fire reported here parallel those recorded from savanna forests of monsoonal Australia (Andersen, 1991). Compared with unburned savanna, annually burned sites have higher species richness and a far greater abundance of *Iridomyrmex*, with sites burned every 2 years supporting intermediate communities. Annually burned savanna supported DD3GM communities (Andersen, 1995), as did the annually burned site in the present study. Unburned savanna supported DD1GM communities (Andersen, 1995), with Generalised Myrmicinae being the most abundant ants, rather than Opportunists as was the case in our unburnt site. We attribute this difference to the warmer climate, and generally higher abundance of Generalised Myrmicines, of the monsoonal region.

Ants as bio-indicators in forestry management

Our study has shown that ant communities are sensitive to fire management practices in Bauple State Forest, thus satisfying one of the major criteria for selection of suitable indicator taxa. Importantly, we have also demonstrated that an effective ant-sampling program is a practicable option. Without any experience in invertebrate survey and systematics, one of us (the senior author) was able to run the sampling program and effectively sort specimens to species, after some initial training and further consultation with a specialist (the second author). Moreover, the use of functional groups within a general framework of community classification in relation to environmental stress and disturbance (Andersen, 1995), means that patterns of community composition could be interpreted without detailed knowledge of the biology of individual species.

In the future, we intend to test the suitability of using ant community responses to detect the more subtle impacts of forestry management practices. Using the results of the present study as baseline data, we have commenced an ant sampling program to monitor a replicated experiment involving the manipulation of fire and cattle grazing.

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